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HIGHLIGHTS OF THE 1985 COTTON INSECT RESEARCH AND CONTROL CONFERENCE

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Foreword

This is the first annual report under the new format approved by conferees in 1984 for reporting the proceedings of the Cotton-Insect Research and Control Conference. In this new format, the annual report will be limited to 1) a revised insect losses statement, 2) a summary of the recent insect and crop conditions in the states, 3) changes in pesticide registrations and insect control recommendations since the most recent full report (in this case the 37th Annual Conference Report on Cotton-Insect Research and Control published in 1984), 4) a listing of promising new pesticides, and 5) a brief summary of significant research accomplishments and progress in on-going research projects by state and federal organizations. In addition to this annual report, a new publication will be developed to up-date and expand the control, biological, and survey information contained in the last full report. The latter publication is projected for revision and publication on a three to five year basis.

The information contained in this report is taken entirely from summary statements provided by representatives of state and federal research or extension organizations across the USA cotton belt.

Crop and Arthropod Pest Conditions

Alabama. - Cotton was planted late (May 12-30) and was slow developing because of early-season cool, wet weather. July was cooler than normal with adequate moisture and August and September were extremely dry, resulting in a loss of a top crop in many fields.

Boll weevil numbers were extremely low throughout most of the season. Controls were not needed until the F_3 generation in August and then only on about 30-40% of the acreage. Bollworms and tobacco budworms were extremely heavy in June and early July, but were unusually light for the remainder of the season. Thrips were very heavy on seedling cotton; even after using a systemic insecticide, some growers had to make 2-4 foliar sprays. From peak bloom (late July) aphids and fall armyworms were the major pests. Whiteflies and spider mites also reached damaging levels on a significant number of acres. European corn borers and beet armyworms were at economic levels in one county each.

Arkansas. - Thrips were high in some fields especially where in-furrow applications of aldicarb were not made at planting. Fields not treated with aldicarb required 1-3 applications of insecticides to control thrips. Plant bug infestations were scattered and ca. 30% of the fields were infested with moderate population levels. Populations of the boll weevil were low because of the extremely cold winter; pheromone trap catches were the lowest since 1979 and only a few fields required treatments. Bollworm captures were high in pheromone traps in Jefferson, Desha, and Drew counties from June 20 to July 20; during this time 30 traps averaged 150 moths/trap/night.

California. - Pest population pressure on cotton was relatively low during the 1984 season. The strawberry spider mite was abundant in some southern San Joaquin Valley fields early; later in the season spider mite population pressures varied from area to area but did not present serious problems. Lygus bug problems were observed in some late planted fields in Fresno, Kings, and Kern Counties. Localized infestations of the bollworm occurred in Fresno and Kern Counties. The beet armyworm was encountered over a wide area of the central valley on several crops during the period of September-October and on cotton became a problem in portions of Fresno, Kings, and Madera Counties.

Georgia. - Approximately 200,000 acres of cotton were planted and 184,000 acres will be harvested. Yield is currently forecast at 584 pounds of lint per acre, a 20% improvement over 1983. Planting dates for the 1984 crop ranged from mid-April to July, with most planted during the first three weeks of May. High temperatures in June accelerated development and three weeks of drought had minimal effects because cotton had not begun blooming.

1984 will be remembered for the lack of boll weevils through most of the season. This is attributed to several factors: 1) unusually cold weather which prevented many boll weevils from surviving the winter, 2) the later planting dates, and 3) hot, dry weather in June that destroyed most of the larvae before they became adults. Most fields were not treated until the third generation emerged in early August. Thrips problems were average but many fields required treatment for tarnished plant bugs and cotton fleahopper. Cotton suffered from a heavy tobacco budworm moth flight in early June and from both budworms and bollworms in July; however the pressure subsided in August and September. Many growers learned to appreciate the residual properties of the pyrethroids and the lack of weevils when they found themselves spraying on 7-10 day intervals. Aphids were a problem in mid- and late-season, probably because of the absence of methyl parathion sprays for weevils and the wet, mild weather in July. Fall armyworm infestations were sporadic with few fields experiencing economic losses. Beet armyworms were not a problem in 1984 and only a few fields were treated for spider mites or western flower thrips. Soybean looper infestations developed late in the season, but outbreaks were isolated.

Louisiana. - In general, growing conditions for the 650,000 acres planted were favorable and insect control efforts were successful. Thus, preliminary estimates of a state yield in excess of 700 pounds of lint per acre seem probable.

In early season, thrips populations were moderate to heavy. Unusually cool temperatures in late May tended to compound the damage by this pest on seedling stage cotton. Plant bug populations, primarily tarnished plant bug, were generally moderate although infestations did exceed the economic threshold in many fields across the state. Heavy bollworm infestations developed on ca. 60% of the acreage somewhat earlier than normal, i.e. late June through early July. Heliothis spp. pressure was generally light to moderate for the remainder of the season, and tobacco budworm pressure was light for the entire season. The overwintered boll weevil population was extremely low for Louisiana and state-wide pressure from this pest was generally light throughout the season. However, heavy infestations did develop by season's end in some fields which were not well managed.

In general, economic infestations of aphids and/or two-spotted spider mites were scattered, but the number of fields requiring treatment was higher than normal. Also, the occurrence of mite problems was earlier than normal, i.e. July as compared to August. Heavy populations of western flower thrips developed on ca. 20,000 acres of cotton north of Shreveport in northwest Louisiana. Although infestations caused considerable alarm, the damage potential of this pest could not be determined or measured. None of the insecticides evaluated provided

effective control of western flower thrips.

Mississippi. - About 1.04 million acres were planted in 1984 and preliminary estimates placed the state average at 876 pounds lint per acre. Heavy rains in October reduced this estimate by ca.100 pounds by November.

Except for plant bugs, insect populations were at very low levels in most of the state. Pest survey efforts included 100 Heliothis species traps in fifty locations and over 4,000 boll weevil traps; there were 20 county pest management programs covering about 85,000 acres of cotton.

North Carolina. - Crop year 1984 was highlighted by (1) the expansion of the Boll Weevil Eradication Program (BWEP) into the remainder of North Carolina, (2) heavier and lighter than usual bollworm pressure in northern and southern parts of the state, respectively, (3) low levels of plant bugs and western flower thrips, and (4) relatively high levels of late European corn borers and fall armyworms.

Bollworm pressure in northern N. C. was greater than in recent years despite fairly moderate to low moth numbers. Rank cotton, coupled with high corolla (bloom tag) retention, contributed to high larval establishment. Producer responses with pyrethroids to threshold levels of larvae minimized potentially severe boll damage. A number of producers who let threshold levels climb excessively, and those who elected to use Dipel, in some cases experienced substantial yield losses. Numbers of bollworm applications generally ranged from 2 to 6, as opposed to 0-3 during the past three years in the northern region. In the face of subeconomic levels of boll weevils and light Heliothis pressure, producers in the southern part of the state averaged ca. 3-8 bollworm applications, as compared to a more typical 6-10. European corn borers were a problem throughout the state, accounting for up to 20-35% boll damage in a few fields, an apparent response to high levels released from ca. 2 million acres of field corn into generally rank cotton. Late fall armyworm populations were extremely high in many fields, particularly across northern tier counties. Egg mass counts of 25-30% on terminals and larval counts as high as 30% on large bolls were observed. However, these late August to early September larval populations did not cause economic damage because they occurred mostly as slow developing second and third instars on lower bolls.

Oklahoma. - Drought conditions experienced during the spring delayed the planting of the 1984 cotton crop in Oklahoma. Most of the cotton in southwest Oklahoma was three weeks behind schedule. Drought conditions which persisted the entire summer reduced the yield potential of dryland cotton. Favorable accumulation of growing degree days during August and September would normally allow irrigated fields to produce an average yield; however, an early light freeze in late September will likely reduce cotton yields in much of southwestern Oklahoma.

The severe winter of 1983 coupled with delayed planting reduced the number of overwintering boll weevils. The average number of boll weevils captured per trap in 1984 was 0.02 compared to 323 in 1982. By September, boll weevil populations were noticeable in area fields, warranting treatment in a few fields. Crop lateness reduced thrips problems; however, some fields were treated. Moderate fleahopper populations occurred during July and in some fields were sprayed. Populations of Heliothis spp. varied across southwest Oklahoma; light populations existed in dryland cotton but heavy populations in irrigated fields in the Eldorado area had to be treated as many as five times. Hot, dry weather favored development of two spotted spider mites, especially in fields treated with synthetic pyrethroids. Most fields infested by spider mites during August were treated twice. The western flower thrips reached damaging populations during August and were treated in some fields.

South Carolina. - The Boll Weevil Eradication Program reduced the boll weevil population to the extent that there were no economic infestations in 1984. In contrast, nearly all cotton fields in the state had economic infestations of boll weevils one year ago. All cotton fields received fall diapause treatments in 1983. This spring, pheromone traps were placed around fields at a rate of one trap per acre, and pinhead square treatments were selectively applied to further reduce the number of overwintered weevils. Fall diapause sprays were applied to all of the acreage in the Eradication Area at least one time. About 10% of the acreage received as many as 10 applications.

Damage from Heliothis species was light to moderate this year. This was surprising in light of the extremely wet conditions experienced in July that often interfered with insecticide applications. Most late season boll damage could be attributed to fall armyworms and European corn borers. In August it was common to find 10-15 fall armyworm egg masses per 100 terminals; however, the mortality of newly hatched larvae appeared to be virtually 100% in fields treated with pyrethroids. European corn borer damage was unusually severe. Although generally under 5%, a few damaged bolls could be found in most fields, especially those bordering corn. Thrips were a problem on seedling cotton, but numbers were somewhat lower than usual owing to the severe winter and hard rains in late May and early June. Lygus bugs were a problem in the Piedmont counties. An increase was observed in the numbers of both lygus bugs and cotton fleahoppers found in cotton fields in the Coastal Plains, probably because of the reduction in the numbers of fields being sprayed for boll weevils.

Tennessee. - Cotton planting began the last week of April and was ca. 99% complete by the first week in June. Cotton squaring began slightly behind schedule but by July 22, 97% of the crop was squaring with 25% setting bolls. Much of the harvest has been delayed by rainfall but yields are expected to be ca. 500 lbs./acre.

Generally, thrips (early to mid-season) and tarnished plant bugs (mid-season) were abundant in 1984 compared to the past 3 years. Heliothis spp. problems were generally light. Seasonal occurrence and damage of boll weevils were light in western Tennessee and moderate during late season in middle Tennessee.

Texas. - The 1984 crop is estimated at 3.7 million bales on 4.5 million harvested acres, with an average yield of ca. 400 pounds of lint per acre. Slightly over 5 million acres were planted, but an extensive summer drought throughout the Texas Blacklands and Central Rolling Plains drastically affected production potential and caused producers to abandon significant acreage for harvest.

Insect problems were generally light to moderate in Texas during 1984. Extremely cold temperatures in December and January coupled with drought severely limited the survivability and in-season population increase of several major insect pests. The boll weevil was particularly impacted by these environmental conditions and therefore generally caused limited damage throughout the state. Some areas did require the use of overwintering applications to further suppress weevil populations. Cotton fleahoppers were moderate to heavy in the Upper and Lower Coastal Plains but were generally lighter in the Blacklands. Light to moderate infestations of fleahoppers occurred in isolated fields of the Rolling Plains and East Texas. Heliothis populations ranged from very light in the Rio Grande Valley, Coastal Plains, and Texas Winter Garden areas to a pest of significance in the Blacklands, portions of the Rolling Plains, High Plains, and far west Texas. Some areas of the Rolling Plains and far west Texas experienced long periods of "subeconomic" infestations of Heliothis, resulting in a significant cumulative impact on yield. All synthetic pyrethroids including the newly labeled Cymbush® and Ammo® were widely used throughout the state. Pyrethroids were often applied in oil carriers and provided excellent Heliothis control. Beet armyworms occasionally caused economic damage in the Lower Rio Grande Valley and were especially difficult to control with any labeled material in the Texas Winter Garden Area. The incidence of spider mites infesting cotton generally increased during 1984 in the Lower Gulf Coast, Texas Blacklands, Rolling Plains, East Texas, and Winter Garden area. The incidence and severity of spider mites appears to be associated with the use of synthetic pyrethroids in many areas of the state. The pink bollworm was present in significant numbers throughout the El Paso and Pecos Valleys and to a lesser extent in the St. Lawrence area. Damage by secondary pests was evident in several areas of the state. False cinch bugs, Nysius raphanus Howard, and lace bugs, Teleonemia scrupulosa Stal, caused partial stand loss in the Lower Rio Grande Valley. Tarnished plant bugs continued to damage cotton in isolated

areas of the Texas Blacklands. Whitefly infestations were more significant than any time in the last 10 years on the Southern Plains of Texas. Cotton aphids also extensively infested this area with many fields being treated during early August.

Estimated Damage to Cotton by Arthropod Pests

Insect losses and costs of control are developed annually by state extension service representatives from each of the states in the USA cotton belt. This information is developed under the auspices of the Cotton-Insect Research and Control Conference with support by the Cotton Foundation to help defray expenses associated with development of the data. Estimates of insect damage in 1984 are presented in Table 1.

Additions to Insecticides/Miticides Registered and Recommended for Cotton Pest Control

Insecticides registered by EPA and recommended for use in controlling cotton pests through the 1983 crop year are listed in Table 4 of the 37th Annual Conference Report on Cotton-Insect Research and Control. There has been one new addition to this list during the 1984 crop year. The synthetic pyrethroid cypermethrin, [Ammo® (FMC Corp.), Cymbush® (ICI Americas, Inc.), (±)-[cyano(3-phenoxyphenyl)methyl] cis,trans-(±)-3-(2,2-dichloroethenyl)-2,2-dimethylcyclopropanecarboxylate], received conditional registration during 1984 and was recommended for use in most states at rates of 0.04-0.12 lbs/A for controlling the Heliothis complex. Full registration of cypermethrin is still pending. Another insecticide inadvertently omitted from the aforementioned list is oxamyl, (Vydate®, methyl-2-(dimethylamino)-N-[[(methylamino)carbonyl]oxy]-2-oxoethanimidothioate), which is registered and recommended for use at a rate of 0.25 lb/A for control of cotton fleahoppers and Lygus spp., or 0.125-0.25 lb/A to control the boll weevil.

In Georgia, SLN(24c) registrations were approved for ULV applications of Penncap M® and azinphosmethyl in vegetable oil.

Changes in Established State Recommendations for Insecticides and Miticides Used for Cotton-Pest Control

Arkansas. - In 1984, EPN + methyl parathion (0.25-1.0 + 0.5-1.0 lbs/A) were removed from recommendations for use against Heliothis spp.; fenvalerate (0.1-0.2 lb/A) was added for whiteflies; and aldicarb (Temik® TSX granules, 0.3-0.5 lbs a.i./A) was added for thrips. 1985 recommendations increase the rate of dimethoate to 0.2 lb/A for use against thrips, remove methyl parathion for use on plant bugs, and remove the DeFend® formulation of dimethoate because it is no longer made.

Georgia. - In recommendations for 1985, dimethoate (0.125-0.25 lb/A) was added for aphid control, the Nu-Bait® formulation of methomyl was removed for beet armyworm and Heliothis spp. control because the formulation was discontinued, and vegetable oil as a carrier for ULV applications of azinphosmethyl and Penncap M was added to previously recommended water sprays.

Louisiana. - Recommendations for 1985 include the addition of aldicarb (Temik®) at a rate of 0.5 lbs a.i./A as a granular in-furrow treatment at planting for control of thrips.

North Carolina. - Recommended additions for 1985 include sulprofos (Bolstar®) at a rate of 1.0 lb/A for the fall armyworm, and chlordimeform + methomyl (0.0625 + 0.0625 or 0.125 + 0.125 lb/A) as a supplemental control for bollworms.

Oklahoma. - In 1984, Kelthane (1.0 lb/A) was added for use against spider mites (pending EPA cancellation bearings).

South Carolina. - Recommended for change in 1984-85 is the addition of profenofos (Curacron®) at a rate of 0.5-0.75 lb/A for use against spider mites.

Texas. - In 1985, the following insecticides will be added for use against cutworms (contingent on labeling): chlorpyrifos (Lorsban®), 0.75-1.0 lb/A; cypermethrin (Ammo®), 0.025-0.1 lb/A; fenvalerate (Pydrin®), 0.1-0.2 lb/A; and permethrin (Pounce®), 0.1-0.2 lb/A.

Contingent upon labeling, which is expected soon, most states will recommend adding the following synthetic pyrethroids for use in controlling Heliothis spp.:

(1) Cyfluthrin (Baythroid®, 0.025-0.05 lb/A, cyano=(4-fluoro-3-phenoxyphenyl)-methyl-3-(2,2-dichloro=ethenyl)-2,2-dimethyl-cyclopropanecarboxylate)

(2) Fluvalinate (Mavrik®, 0.055-0.1 lb/A, cyano=(3-phenoxyphenyl)methyl-N-[2-chloro-4-(trifluoro=methyl)phenyl]-D-valinate)

(3) Tralomethrin (Scout®, 0.015-0.02 lb/A, cyano(3-=phenoxyphenyl)methyl 2,2-dimethyl-3-(1,2,2,2-tetra=bromoethyl) cyclopropanecarboxylate)

Insecticides and Miticides Showing Promise in Field Tests

Several of the experimental pesticides reported in the 37th Annual Conference Report continue to show promise in field evaluations. These products include 1) the carbamate thiodicarb (Larvin®, 0.5-1.0 lb/A) against Heliothis spp.; 2) the synthetic pyrethroid FMC-54800 against spider mites and lygus bugs (0.1-0.2 lb/A) and Heliothis spp., boll weevils, aphids, and white flies (0.04-0.06 lb/A); 3) the insect growth regulator CGA-112913 (0.03-0.05 lb/A) against Heliothis spp.; 4) the avermectin MK-936 (0.005-0.01 lb/A) against spider mites; and 5) the synthetic pyrethroid fenpropathrin (Dannitol) against spider mites at rates of 0.1-0.2 lb/A.

Previously unreported pesticides that show promise include 1) ABG-6162 (0.09 lb/A) against spider mites (this is an exotoxin of Bacillus thuringiensis produced by Abbott Laboratories); 2) the synthetic pyrethroid PP-321 (ICI Americas) against Heliothis spp. and boll weevils at rates of 0.015-0.03 lb/A; 3) the synthetic pyrethroid Shell-70616 (0.01-0.02) against Heliothis spp.; and KIC-1736 (K-I Chemical USA, Inc.) against Heliothis spp. at rates of 0.75-1.0 lb/A.

Research Progress and Accomplishments

Arkansas. - Adult male bollworms were collected from pheromone traps located in Arkansas and examined for pollen. Pollen was found on 68.3% of the moths, primarily on the proboscis or eye areas. Pollen of Calliandra (false mesquite) and Pithecellobium (ape's-earring) were found on moths during each of two years. Neither plant occurs in Arkansas; the distribution of Calliandra closest to Arkansas is south central Texas, while Pithecellobium occurs in south Texas near the Mexican border. The presence of the pollens on bollworms indicates immigration from at least 750 km (470 miles) to the Arkansas capture sites. Dissections of these moths showed definite resorption of eggs in the lower parts of the ovarioles and depletion of fat bodies in males. Some observations suggested that viability of eggs and first stage larvae from these immigrating moths was below average. (Univ. AR).

Arizona. - High levels of parasitism of Lygus spp. eggs by the mymarid Anaphes ovijentatus were found on several winter hosts near Tucson, AZ. An average of 23% of the Lygus eggs in cotton leaf petioles were parasitized by A. ovijentatus in four fields near Tucson in late June. The parasitism dropped to 5% in July when the number of eggs suddenly increased. A Delaware strain of Leiophron uniformis, a braconid parasite of Lygus, was 2.7X more effective parasitizing nymphs of Lygus lineolaris than a strain from California. Both strains of L. uniformis were more effective against L. lineolaris from New Jersey than against those from Arizona. Rearing systems have been developed for A. ovijentatus and L. uniformis using packets of Debolt diet to rear the Lygus hosts and to collect Lygus eggs. A meridic diet based on beef products was developed for Geocoris punctipes. Thus far six generations have been reared on the diet with steadily increasing numbers. (USDA-Tucson).

At the ARS Western Cotton Research Laboratory in Phoenix, an attracticide combination of gossyplure, Coax®, and an insecticide produced measurable mortalities of pink bollworm males in cages for as long as 100 days. The mixture applied as a spray, 5 drops of 20 µl, or 20 drops of 5 µl one day after treatment, killed 27, 63, and 66%, respectively, of the males in one night of exposure. Activity was high 2 and 7 weeks after treatment with drops, and some kill was evident 100 days after treatment. One isomer (Z,Z) of the 2-isomer component pink bollworm sex

pheromone reduced male trap catches, rosetted blooms, and infested bolls comparable to that obtained with gossyplure. Also, the Z,Z-isomer applied to cotton fields resulted in a highly significant behavioral modification. Male moths in the Z,Z-treated field responded and were caught in significant numbers in traps placed in the fields containing a 9:1 ratio of Z,Z- to Z,E-isomers as compared to numbers of male moths caught in traps baited with a 1:1 ratio of the isomers. Selection pressure with 9:1 Z,Z- to Z,E-gossyplure for 5 generations did not change pink bollworm male moth catches in gossyplure or 9:1 Z,Z-Z,E-baited traps. A pink bollworm body-color marker strain released in the field survived 2 to 3 weeks in the cotton ecosystem. Hourly trap catches showed no difference in time of response of field or released male moths. The use of eye-marker strains showed that multiple matings most often occurred with the same male. Chlorflurenol at 0.56 kg/ha plus ethephon at 0.14, 0.28, 0.56, or 1.12 kg/ha, or thidiazuron at 0.034 kg/ha, effectively stopped fruiting until harvest. Ethephon and thidiazuron, alone or in combination, stopped fruiting at application, but permitted new plant growth and fruiting within 10 to 15 days. Untreated plants produced more seed cotton and lint because they set additional fruit in September, but the late-set bolls would have produced nigh numbers of diapausing pink bollworm larvae. Double-row beds produced only slightly more cotton than single-row beds because the plants grew relatively tall and covered the soil early with both spacings. The average seed cotton and lint yields were much higher from the March 21 planting (3.4 bales/acre) than from the May 3 planting (2.4 bales/acre).//A small plot test showed that a population of Heliothis larvae was controlled by mixed microbials, insecticides, and a feeding stimulant. Doses required were 2.4 x 10^8 polyhedra (nuclear polyhedrosis virus), 227 gm of Bacillus thuringiensis (1.6 x 10^4 international units/mg), and 454 gm of adjuvant (feeding stimulant)/A. A laboratory study to test the virulence of a baculovirus from the alfalfa looper showed that there was no loss in activity when stored frozen for several years. This compares to a detectable loss of activity after three months using standard methods (not frozen). Also, when formulated in Coax, virulence of the virus was consistently greater than standard virus formulations when stored at room temperature or in a refrigerator (34-38°F). Preliminary results of a study to determine the interaction of B. thuringiensis and insecticides on mortality of Heliothis larvae indicate that acceptable levels of control may be obtained with lower levels of insecticides (ca. 1/5-1/10 of standard rate).//Bollworm adult emergence began on August 5 and ended on August 17. A maximum number of 376 moths/acre emerged on the night of August 9. Most of the emergence occurred over a 5-day period between August 7 and 12. The moths emerged between 8:30 p.m. and 2:00 a.m. and took short flights at about 1-1/2 hours after emergence; however, they did not leave the field until 15-30 minutes before daylight. After emergence, 14.6 minutes elapsed before the moths had fully expanded their crimped wings. The wings remained expanded for 2.3 minutes and then were extended overhead and held in that position for 24 minutes. They were then returned to the normal resting position and the moths took a short flight after resting for 1 hour, 36 minutes. Except for the short flights, the moths remained on the stalks until 4:30 a.m. where they were docile and easy to observe. Some moths were observed probing exudates from the stalks with their proboscis while their wings were still crimped.// At Phoenix, boll weevil adults emerged from infested bolls on the soil surface from December to May and mortality was about 95%. Few weevils survived when weevils were buried in soil 3 inches deep. Peak catch of boll weevils in traps occurred January-February, decreased in March, and few were caught when cotton was actively growing and fruiting. Catches increased in late August to September and thereafter when cotton was maturing. Longevity of weevils was greatest when fed cotton squares and bolls as compared to globe mallow and cotton terminals. Cotton fruiting forms as food were essential for reproduction.//Sweetpotato whitefly parasites were collected, the magnitude of the populations determined, and their role as natural population regulators is being determined. Preliminary studies indicate that certain insecticides may induce higher whitefly populations in cotton. Two insect parasites of the beet armyworm and two of the pink bollworm were released. (USDA-Phoenix).

California. - In the San Joaquin Valley, spider mite studies devoted to forecasting the development of damaging populations and field evaluation based upon presence/absence on leaf samples were continued with preliminary positive results. Evaluation of resistance to acaricides in spider mite populations was continued.//Lygus bug populations in wild lands were sampled and evaluated and a forecasting technique was developed.//Studies evaluating the response of the cotton plant to feeding damage caused by Heliothis and spider mite species were continued.//In southern production areas, boll weevil populations were monitored and gossyplure was further evaluated, alone and in combination with insecticides, as a suppressant for pink bollworm populations. (Univ. CA).

Georgia. - Corn earworm male and female adults were exposed to substerilizing doses of gamma radiation. The inherited deleterious effects in the progeny of irradiated male and female lines were compared for several generations. A theoretical model used to assess the feasibility of employing these genetically altered insects and their respective progeny in corn earworm control indicated that a single release of these insects could produce suppressive action for at least three generations. (USDA-Tifton).

Heliothis spp. control in cotton was achieved using several pyrethroid insecticides that were injected into irrigation water and applied through center pivot systems. Rates as low as half of the recommended dose were found to provide good Heliothis control. The boll weevil was not as easy to control using "chemigation"; fenvalerate, permethrin, or cypermethrin did not provide adequate control using adequate control using standard rates. The addition of Penncap M or a standard formulation of methyl parathion increased boll weevil mortality, but heavy populations are not easily brought under control using these compounds. Cyfluthrin provided excellent boll weevil control when applied alone through the pivot system.//Dosage mortality studies indicate no changes in susceptibility of H. zea or H. virescens to the pyrethroids from baselines developed as far back as 1978. Studies are continuing to establish baseline data for all new materials which are near registration for cotton insect control. One finding of significance is that for several of the newer pyrethroids, a straight line ld-p curve can not be obtained using the standard ESA protocol procedures. These curves were found to be bell-shaped. When moribund larvae are included in the mortality figures, a linear relationship may be found. Results such as these may be a reason for revision of the ESA testing protocol. (Univ. GA).

Louisiana. - Vegetable (cottonseed) oil was compared to water as a carrier for aerially applied insecticide for the fourth and probably final year. Conventional 2 GPA water-based applications of cypermethrin at 0.06 lb/A were compared to the same rate applied ULV in oil (1 qt/A) in a randomized, replicated aerial test. Both treatments performed equally well against Heliothis spp. and boll weevils. Neither treatment gave adequate control of aphids, and spider mites increased in both treatments until suppressed by rain and disease. Thiodicarb at 0.6 lb. AI/A applied by air in large scale EUP plots worked well on low Heliothis spp. infestations, but higher rates were needed when the infestation increased. Tralomethrin (0.15-0.19 lb/A) and cyfluthrin (0.03 lb/A) gave good control of low to moderate Heliothis spp. infestations in large scale EUP plots when applied by air. (LSU).

Mississippi. - The tarnished plant bug was the major cotton pest in the central Mississippi Delta during 1984. Effective control was obtained with two pyrethroids and an organophosphate. When plant bugs were not controlled, yield of seed cotton was reduced over 20% and crop maturity was delayed by two weeks. Chlordimeform applied early season increased yield 10% over untreated cotton.// Occurrence of the bollworm and tobacco budworm on early-season host plants has been fully elucidated. Removal of the host plant through mowing or with herbicides, and application of the Heliothis nuclear polyhedrosis virus, has provided suppression in small plots.//Microplitis croceipes, a parasite of Heliothis spp., was successfully labeled with several trace elements (cesium, rubidium, and strontium) by adding them to the diet of Heliothis larvae on which the parasite was reared. The presence

of the label was detected using atomic absorption spectrophotometry. The labels persisted for the lifetime of adult wasps in the laboratory, but they had no effect on the development rate or survival of the parasite. The parasites can be reared and labeled in large numbers without special handling. This labeling technique is now being used in a mark-recapture study on the dispersal and survival of M. croceipes as a function of Heliothis density in the field. Studies are also being conducted using M. croceipes sex pheromone to monitor populations of adult wasps. This information will be important to pest management in cotton. In addition, toxicological tests are being conducted to determine which insecticides are tolerated by parasitoids which attack Heliothis spp. larvae in cotton.// Large-scale rearing procedures for the sterile backcross have been developed and releases of the backcross on an island (St. Croix, V.I.) caused suppression of the tobacco budworm by infusion of the sterility trait. Present research is directed toward establishing the density of emerging tobacco budworm populations in the central Mississippi Delta and measuring dispersal of the moths (particularly the females). Other population ecology studies are being conducted to provide baseline data for conduct of a state-wide test to assess the technical feasibility of maintaining tobacco budworm populations in cotton at subeconomic levels through sterility infusion.//Genetical characterizations and crossing experiments among species within the H. zea complex (=Helicoverpa subgenus) are being conducted. Foreign exploration, importation, and laboratory colonization of exotic Heliothis species is being conducted in order to obtain material for hybridization experiments and backcross trials which form the basis of our search for a hybrid sterility mechanism. Biosystematic studies include taxonomy, pheromone biochemistry, measurement of mitochondrial DNA, and cytology of spermatogenesis. The long range purpose of research on genetics and cytology of sterility in the bollworm complex is to contribute to an understanding of the unique mechanism of maternally inherited backcross of the sterility trait within other economically important species. Although the immediate research goal is to develop genetic control mechanisms for the bollworm, the experimental design is equally likely to generate information applicable to the control of exotic bollworm species. Heliothis armigera has been imported into SRQF and it did intermate with H. zea (H. armigera female x H. zea male); however, fertility was low. Hybrid progeny are being tested for sterility. (USDA-Stoneville).

A mass rearing procedure has been developed which allows stockpiling of the boll weevil. The procedure is based on reducing larval rearing temperatures to delay adult emergence from thirteen days to forty-two days following tray preparation. The cold-reared weevil may have a slightly enhanced vigor over the standard weevil. The delayed development procedure permits: 1) stockpiling weevils prior to field release program, allowing an initial weevil population several fold greater than would be otherwise possible, 2) maintenance of a stockpiled population to be drawn on in the event of an unexpected greater demand of treated weevils for field release, or to be used in the event of major rearing equipment failure and repair, and 3) a significantly reduced cost of culturing the boll weevil during non-mass release periods when colony continuity is required as well as supplying weevils for research purposes.//Streptomycin sulfate was found in both tissues and blood of boll weevils fed antibiotic treated diet. Metamorphic changes from larva to pupa to adult were accompanied by decreases in the antibiotic concentration. Eggs from adults reared as larvae on the antibiotic diet were free of antibiotic.//A ground release procedure has been developed for possible use with the boll weevil eradication program. Sexually sterilized weevils, suspended in a viscous fluid, are released directly onto the cotton plant from dispersing equipment mounted on a one-row High Boy. (Weevils released by free fall aerial drop can become immobilized in loose sandy soil and ground temperatures in excess of 46°C can kill weevils in seconds after reaching the soil surface.) The cost of the dispensing procedure is estimated to be $0.50/acre per release (equipment amortized over a three year period) and one unit can cover up to 2,000 acres with a predictably uniform dispersal. The procedure was successfully field tested during the 1984 crop season. Its immediate application is that of supplementing a sterile boll weevil aerial release program which could not be implemented in certain areas due to weather, terrain, etc. This ground release procedure may be applicable to release programs using other insects. Sterile boll weevils were released every 5 days for 41 days in 100 acres of commercially grown cotton in Choctaw County, MS. Three fields totalling ca. 50 acres were used as controls. Egg hatch was reduced to 37% in the treated fields while hatch in the control fields averaged 83%. In small plot studies comparing the competitiveness and longevity of boll weevils treated with 4, 5, 8, or 10 Krad, all had similar competitiveness.//Studies were made of the effect of staphylococcal enterotoxin-B on pheromone production in fat bodies isolated from male boll weevils. In this recently completed study, the enterotoxin caused a significant ($p<0.05$ by t test) decrease in pheromone production in incubating fat bodies from male boll weevils. The significance of this finding is that the bacterium that produces this toxin has frequently been found to contaminate boll weevils from the Gast Rearing Facility.//Pheromone production from 1-10 day old field-collected (as immature weevils) male boll weevils fed entirely on greenhouse and field grown cotton squares (buds) has been found to be very low (approaching zero) in native male boll weevils emerged from field collected cotton squares collected during September and October, 1984. These weevils were observed to be in diapause. Other weevils collected by hand and in infield pheromone traps were found to produce almost no pheromone during this period. This could, in part, explain the dispersal behavior of late-season boll weevils. Electroantennogram (EAG) techniques were utilized to measure antennal olfactory responsiveness of adult boll weevils to 38 odorants including both insect and host volatiles. Results indicated at least 2 separate receptor populations for pheromones and plant odors for each sex. Receptor systems for each sex were similar. However, females were slightly more sensitive to one component of the aggregation pheromone than were males while males were slightly more sensitive to selected plant odors than were females; β-bisabolol and heptanal were the two most active plant odors tested. A new dual choice laboratory behavior bioassay was developed for the boll weevil. Initial results indicated both males and females were attracted to grandlure while only males were specifically responsive to plant odor at the concentration tested. However, when offered a choice between the pheromone and the plant, response to the pheromone clearly predominated. Topical application of a juvenile hormone analog (JHA) depressed response of the boll weevil to pheromones and plant odors. This is significant since fluctuation of endogenous JH levels could modulate antennal sensitivity and olfactory-mediated behavior.//In recent months, some grandlure procured commercially has been shown to be less attractive in both laboratory and field tests. and therefore potentially less effective for field programs. Chemical work was initiated to determine the reason(s) for the decreased potency. As a result, a number of components were isolated and identified as present in small quantities in the commercial pheromone preparations. They were subsequently synthesized for proof of structure and bioassayed in the laboratory as additives to pheromone preparations known to be highly active. Several of the compounds decreased the potency to 50% or less at levels that have been found present in the commercial preparations. Therefore, these results provide a basis for gaining better quality control during the commercial synthesis, and the compounds themselves may be of interest for subsequent behavioral investigations.//Research on pheromone-trapping was conducted to improve the measurement and prediction of overwintered boll weevil emergence and to determine how this measurement relates to actual damage in the field. Two locations in east-central MS were divided into 62 one acre plots. Prior to cotton emergence, one pheromone trap/acre was placed around the border of each location field. After plant emergence, traps were moved into each plot (1/acre) and monitored weekly through the second week in October. The number of ovipositional-size squares/30 ft of row was determined by manual inspection, and a systematic mechanical sample was taken on 4600 row feet/acre/week. Overwintered emerging weevils peaked the third and fourth week of June with a total of 174

weevils captured in traps for the two locations; weevils were detected in 96.5% of the plots. No damage was found by the hand sample but 19.5% of the acreage had detectable damage with the machine sample. Trap averages from emergence to pinhead square stage were less than 0.5 weevils/trap/week, and damage was less than one-half percent. No weevils and no damage were recorded in 3.5% of the plots. No in-season control for boll weevil was needed at either location.//The pentane extract of freeze-dried cotton buds or anthers yielded by column chromatography a wax-sterol fraction that exhibited potent feeding stimulant activity for the boll weevil. The waxes of the wax-sterol ester mixture were responsible for the feeding activity. Saponification of the wax-sterol ester fraction yielded about 15% alcohols and 85% sterols. A $C_{18:1}$ alcohol, dihydrophytol, phytol, and geranylgeraniol constituted 15, 36, 26, and 23%, respectively, of the total alcohols, thereby implicating certain long-chain esters as feeding stimulants. Several esters of dihydrophytol, phytol, and geranylgeraniol were identified among the waxes by GC-MS. Some of these esters were synthesized and were found to induce feeding activity in the boll weevil.// The antimicrobials tetracycline, erythromycin, neomycin sulfate, metronidazole and penicillin V were mixed with H. virescens (F) diet, and their effects upon larval development, pupation, adult emergence and egg hatch were measured. Low doses (0.05% W:W) of antimicrobials had no effect upon weight of larvae and pupae or upon number of days required to reach the pupal stage. Low doses of tetracycline reduced adult emergence and metronidazole reduced egg hatch. With a few exceptions, high doses (0.8% W:W) had negative effects on all parameters tested. (USDA- Mississippi State).

Work on insecticide resistance management strategies for Heliothis is continuing. One approach that is increasingly attractive is the use of combinations of pyrethroids with chlordimeform or methomyl at ovicidal rates. Research has been initiated to study the impact of early season insecticide applications on arthropod populations and cotton production. Preliminary results suggest that prophylactic applications of some insecticides during early season will result in early fruit set. However, these applications may also stimulate outbreaks of aphids and spider mites, and in some cases untreated plots can compensate for early fruit loss.//Research is continuing on the role of natural enemy predation in the regulation of Heliothis spp. populations. Small plot studies conducted in 1984 in Oktibbeha Co., Mississippi, revealed that prey density had little effect on the predation rate on eggs or larvae. Results of some tests indicated that 2X more larvae were consumed than eggs.// Studies conducted to determine the effect of Lygus lineolaris feeding on cotton fruit retention suggest that L. lineolaris adults can cause ca. two fruiting structures to abort per day on an individual basis. The data corroborate those reported earlier for L. hesperus in the western regions of the Cotton Belt.// Experiments have been completed that describe the effects of temperature, growth stage, and insecticide use rate on mortality of Heliothis spp. exposed to fenvalerate, permethrin, and methyl parathion. These data should be useful in development of simulation models. Efforts to use the CIM model in "on-the-farm" decision making are continuing. Plans to use information gained by using the model "on-line" will be incorporated into a model written for hardware which can be used by producers and others in the cotton industry. (MSU).

North Carolina. - Population dynamics studies were initiated in 1984 to investigate the potential of western flower thrips, plant bugs, and stink bugs to develop into economic pests as a result of elimination of early insecticide applications against the boll weevil. //Bollworm threshold levels in the absence of the boll weevil are being evaluated in the two major ecological regions of state.//European corn borer damage to cotton bolls was found to be related to fertilizer rate and cotton plant maturity. (NC State).

Applied research was conducted in North Carolina, and especially in South Carolina, to support boll weevil eradication efforts in those states. Insecticide applications to prevent boll weevils from entering diapause were initiated in late August and completed during November, 1983. Because of the early initial applications and the prolonged warm temperatures experienced in the fall, up to 13 treatments were made. During this same period, traps were located around cotton fields at (1 per 10 A) and an average of 50 weevils/trap captured. In the spring of 1984, operations were intensified with one trap/A located around all 1983 field sites as well as around 1984 cotton acreage. Boll weevil captures up to the pinhead square stage totaled less than one weevil/10 A in the eradication zone. Eighteen percent of the cotton acreage received treatments at pinhead stage to prevent reproduction. Depending on the location and number of weevils captured, various combinations of organophosphorus insecticide and/or diflubenzuron applications were utilized in these treatments. Evidence of reproduction, based on capture of boll weevils in pheromone traps, was not apparent until early August. In order to protect adjoining fields, treatments were applied immediately to those fields with suspected boll weevil reproduction. Chemical applications to prevent boll weevil diapause were started the week of September 10 on 20% of the acreage. The acreage involved in treatment increased to 60% by the last application in mid-November. As an extra precaution against migrating weevils, all cotton acreage received one diapause treatment in late October. An average total of one weevil/A was captured from August through November 15 of 1984 in cotton in the Eradication Zone. However, weevils were not detected on almost 25% of the fields.//A computer system for storage and retrieval of data generated by the eradication program was implemented in January 1984. Procedures were established for reporting boll weevil captures on a daily basis. This timely information facilitated a more accurate and comprehensive response to eliminate surviving boll weevils. Every cotton field in North Carolina and South Carolina is included in this system.//Modifications and improvements to the boll weevil pheromone trap have been evaluated and adopted for use in 1985. These changes resulted in improved trap utility and reduced costs. This new trap will be manufactured with interchangeable plastic component parts; the metal screen will be retained. Pheromone dispensers from Pest Select Co. and Hercon Corp. were evaluated in field trap tests. Results indicate that both commercial dispensers as well as the cigarette filter dispenser developed by ARS are suitable for eradication program use. (USDA-Raleigh).

Oklahoma. - Six cultivars of upland cotton were tested for preference by the cotton fleahopper. The cultivars were Westburn M, Stoneville 213, Deltapine 90, Paymaster 145, Camd-E, and frego bract. The test was a split plot in a randomized complete block design, with half the plot protected throughout the growing season by treatment with insecticides. Camd-E and frego bract were preferred for oviposition and Deltapine 90 and Westburn M were least preferred. No correlation could be determined with any of the morphological characteristics of the cultivars. Over 160 experimental lines of Westburn M - High Tannin crosses were evaluated for resistance to H. zea ; 22 of the lines showed some degree of resistance. The role of high tannin in bollworm resistance is still in doubt because, although growth of the bollworm larva is retarded, damage remains high.//A new simulation model was developed that allows distribution- free computer simulation. This model allows various limiting factors to be included in the model. For example, the number of insects per plant can be restricted. Several models were developed based on field collected data. It is expected that 2-3 more years of verification in the field are needed. Computer simulations were run for a wide range of means on the geometric, negative binomial, Poisson, binomial, and logarithmic discrete distributions. Recommended transformations were compared to raw data and the Conover-Iman rank transformation for numerous situations with the randomized complete block design. None of the methods prove to be best for all situations. One clear trend was that the standard transformations were shown to have less power than the other two methods for all distributions. The rank transformation method seemed to have the greatest power on small data sets, while raw data worked best on large data sets.//Eleven treatments consisting of chemicals tested individually or in combination were evaluated for control of the Heliothis complex. Cyfluthrin at 0.025 lb/A plus sulprofos at 0.15 lb/A, PP-321 at 0.02 lb/A, and cyfluthrin 0.025 lb/A plus chlordimeform at 0.125 lb/A gave the best control. (OSU).

South Carolina. - The insect growth regulator CGA-112913 combined with chlordimeform showed promise for Heliothis spp. control. Four new synthetic pyrethroids (cyfluthrin, FMC-54800, PP-321, and tralomethrin) were effective against a moderate infestation of Heliothis spp. Fenvalerate applied as a foliar spray at 0.0375 lb/A was equally toxic to Heliothis spp. larvae that were reared on the following cultivars: Coker 315, Stoneville 825, Pee Dee 875, Pee Dee 695, JBN 3-way Cross (CMS, PD 695 x BW 72-3560 x Early Pima Restorer), BW 76-31, SC 1, Coker gl 80-501, La gs 80-4N and PD-2.//Tests with pheromone traps for the boll weevil showed that a dose of 10, 20, or 30 mg per trap did not affect the numbers of weevils captured with a population of <0.03 weevil/trap/week. Overwintered female weevils responded up to 17 days after release in 2-ha test plots of cotton. When 2 or 4 females were released in test plots, all were recaptured.//Nutritional studies to determine feeding preferences have shown that casein is not a preferred protein but wheat germ is a feeding stimulant. (USDA-Florence).

Texas. - In tests at College Station, PP-321 (a new pyrethroid from ICI Americas with a structure similar to cypermethrin) has shown good activity against boll weevil and Heliothis at lower rates than cypermethrin. Thiodicarb at 0.6 lb/A was about as active as cypermethrin at the same rate for Heliothis. The pyrethroid materials, PP-321 and cyfluthrin, were more effective than azinphosmethyl for control of boll weevil. This may be due to the residual of the pyrethroids as treatments were made on a 5-day schedule.//Several experimental and labeled insecticides were evaluated at Weslaco for efficacy against cotton pests and also to determine their impact on beneficial arthropods in small-plots treated with ground equipment. Results of early-season tests indicated that applications of cypermethrin, PP-321, and MO-70616 (fenvalerate) were efficacious against the pest complex and resulted in yield increases over untreated plots. Results of late-season tests indicated that all test materials provided control of the cotton leafperforator. Cypermethrin and PP-321 significantly reduced beneficial arthropod populations. //Populations of western plant bug were almost non-existent in Rio Grande Valley cotton fields and weedy areas during 1984. A hard freeze in December, 1983, probably caused the population decline of this tropical species by impacting on the insects and/or their alternate host plants. Populations were present on cotton and weeds in 1983.//Aluminum trays (1m x 1m) were evaluated at Weslaco as sampling devices for determining differences in boll weevil mortality or knock-down in small plots treated with different rates of insecticide. Regression analysis using data from tray counts of dead weevils indicated a highly significant relationship between number of dead weevils and insecticide application rate. Results of analyses using data from other sampling methods (live weevil counts, fruit damage, yield) were not significant.//At College Station, fleahoppers were controlled at different node age of cotton: 7, 9 and 10. Cotton responded (in increased blooming) only where insecticides were applied at node 7. (TAMU).

Several improvements have been made in artificial diets for the tachinid, Eucelatoria bryani. The cost of the diet has been reduced and yields of apparently healthy adults consistently have reached 55-70%. The tachinid Palexorista laxa has been reared in vitro to the adult stage for the first time. Rearing containers and techniques have been developed which have good potential for allowing Trichogramma pretiosum to be reared efficiently in vitro on a large scale. Good progress has been made toward the development of an artificial diet devoid of insect components and recent research has provided an important lead for greatly increasing yields of parasites on artificial diets.//Tobacco budworms preferred garbonzo bean plants (chickpea) to cotton plants as oviposition sites in small cage tests. A methylene chloride extract of garbonzo bean terminals and fruiting forms elicited an ovipositional response in tobacco budworm moths in laboratory tests.//Addition of small quantities (less than 1% of total pheromone) of Z-11-hexadecen-1-ol to virelure (Z-11-hexadecenal and Z-9-tetradecenal, 16:1 ratio) resulted in significantly increased trap catches of tobacco budworm males when formulated in a plastic dispenser. Addition of larger quantities of Z-11-hexadecen-1-ol resulted in reduced trap catches of tobacco budworms.//A survey of parasites emerging from Heliothis eggs collected from different cotton-growing areas in Texas (conducted cooperatively with Texas Agricultural Extension Service entomologists) indicated that the predominent egg parasite was Trichogramma pretiosum Riley. Possibly a new and as yet unidentified species of Trichogramma was recovered from eggs collected on cotton in the High Plains. This may be the same species that parasitizes eggs of the southwestern corn borer on corn in the area.//Doses of avermectin, the insect growth regulator CGA-112913, or permethrin were administered orally to 5th stage bollworm larvae that were not parasitized or that had been parasitized 18-24 hours previously by the internal tachinid parasite Palexorista laxa. Avermectin caused little mortality among the unparasitized larvae but significantly reduced normal pupation. Parasite development in treated larvae was significantly reduced in surviving parasitized larvae and appeared to be dose dependent. CGA-112913 had a more pronounced effect on pupation of unparasitized larvae but had little effect on development of parasites. Permethrin caused significant dose dependent mortality in unparasitized larvae but had little effect on parasite development.//Studies of the response of tobacco budworm, bollworm, and fall armyworm larvae to avermectin indicated topical LD_{50} doses for 72 hour mortality responses among 3rd stage larvae were 0.032, 0.206, and >>10.0 µg/insect, respectively; and for delayed morphogenic effects were <0.025, 0.108, and 62.3 µg/insect respectively. Following oral administration of avermectin to last instar larvae of the same species, the LD_{50} doses for 72 hour mortality were 0.501, 15.039, and >>10.0 µg/insect, respectively; and for delayed morphogenic effects were 0.081, 1.405, and 28.5 µg/insect, respectively. Studies of absorption, metabolism, posttreatment distribution and elimination, and receptor-binding are being pursued to determine reasons for differences among these species in susceptibility to avermectin. (USDA-College Station).